

NOAA Technical Report NOS 129 and 14



Integrated Triangulation Software (ITS) User's Guide

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National Ocean Service, NOAA
Rockville, MD
January 1989

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AVAILABILITY

The User's Guide for the Integrated Triangulation Software combines two programs, the General Integrated ANalytical Triangulation (GIANT) and the General Cartographic Transformation Package (GCTP). In addition, the interactive full screen data entry facility enables easy and error free data entry for triangulation run options.

Accompanying this document are the GIANT User's Guide, NOAA Technical Report NOS 126 CGS 11, the GCTP/II User's Guide, NOAA Technical Report NOS 124 CGS 9, and a nine track magnetic tape, recorded at 1600 bpi, in object code, containing directories of object code, command procedures, and support data files. Magnetic tape will be generated using DIGITAL/VMS/BACKUP facility.

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PREFACE

This user's guide addresses the needs of those individuals with a photogrammetric background who will be executing the Integrated Triangulation Software (ITS) for photogrammetric triangulation. Since the ITS triangulation program integrates the General Integrated ANalytical Triangulation (GIANT) program (Elassal and Malhotra 1987) and the General Cartographic Transformation Package, (GCTP), Version II (Elassal 1987), using the Screen Data Editor (Keltz 1987/appendix C) for interactive data entry, the user must be familiar with these three software programs. In order to use ITS, the documents for these software programs must be consulted.

This document is kept as simple as possible for a better understanding of the interactive data entry process. Step-by-step instructions have been added for a typical triangulation project. The chapter on data editing and run strategies gives some useful pointers for the user.

The software for ITS was developed by Dr. Atef A. Elassal, based on GIANT and GCTP/II. Mr. Michael A. Keltz added the capability of interactive data entry by the use of the Screen Data Editor.

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INTEGRATED TRIANGULATION SOFTWARE (ITS) USER'S GUIDE

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ABSTRACT. The existing National Ocean Service programs, the General Integrated ANalytical Triangulation (GIANT) and the General Cartographic Transformation Package (GCTP), Version II, have been integrated into a single Integrated Triangulation Software (ITS) program. This ITS program has an additional facility of full screen interactive data entry using the Screen Data Editor software developed in-house. The ITS program is an enhancement of the GIANT aerotriangulation program, to which cartographic transformation and interactive data entry features have been added. Four of the five input data files, CAMERAS, IMAGES, FRAMES and GROUND are created in the edit mode exactly the same way as in the GIANT program. The fifth file, COMMON, is created interactively by the operator, who enters run options in the various data fields displayed on the CRT screen. The ITS capabilities and restrictions in aerotriangulation are dictated by those of the GIANT program. It also restricts transformation of geographic coordinates to any of the 20 other reference systems in GCTP/II.

The ITS and the Screen Data Editor are implemented in the VAX/VMS operating system environment of the Digital Equipment Corporation (DEC). Due to the requirements of the Screen Data Editor, the user terminal must be compatible with the DEC VT100.

A discussion of the overview, data flow, step-by-step procedure for aerotriangulation, and data editing and run strategies, guide the user through the program. Appendices give the various GCTP reference systems, description of GIANT program for capabilities and restrictions, and explanation of the data fields in the aerotriangulation data screen display for interactive data entry.

I. INTRODUCTION

This is a user's guide for the Integrated Triangulation Software (ITS), an on-line interactive aerotriangulation program. This program is an integration of the software for General Integrated ANalytical Triangulation (GIANT) (Elassal and Malhotra 1987), and the General Cartographic Transformation Package (GCTP), Version II (Elassal 1987). Screen Data Editor software forms a part of the ITS.

It allows full screen interactive data entry for input as well as output for aerotriangulation runs. A Screen Data Editor User's Guide (Keltz 1987/appendix C) has been written to facilitate data entry.

The ITS and the Screen Data Editor are implemented in the VAX/VMS operating system environment of the Digital Equipment Corporation (DEC). Due to the requirements of the Screen Data Editor, the user terminal must be compatible with the DEC VT100.

To understand the functions, capabilities, and limitations of ITS, the user must understand its first phase, the GIANT program for aerotriangulation. The input coordinates and camera attitude angles are in an object space coordinate system, which could either be the geographical latitude/longitude system for large area projects or a local rectangular coordinate system for close-range photogrammetry. Data reduction is carried out in the object space coordinate system of the input data. The output from the triangulation phase, the GIANT program of ITS, is also in the object space coordinate system of the input data. However, in the next phase of ITS the GCTP is executed and the user has the option to transform only the geographic coordinates into any of 20 different map projections supported by GCTP (appendix A).

The user must also be conversant with the Screen Data Editor for full screen data entry, and the selection process for the run options from the item list for each of the fields appearing on the screen. In accordance with the instructions given in the GIANT User's Guide, full screen display entitled GIANT - AEROTRIANGULATION is used for creating the input COMMON file for the GIANT aerotriangulation run. In a typical aerotriangulation project using ITS, multiple runs are performed. At first, input data are edited by selecting appropriate run options only for the INTERSECTION solution. Run options are then selected for AEROTRIANGULATION, but without a complete statistical analysis. Finally, run options are selected to include statistical analysis as well as the coordinate transformation by GCTP. This phase of data reduction for aerotriangulation is discussed in greater detail in chapter VI entitled Data Editing and Run Strategies. The Screen Data Editor enables the user to enter the run options interactively for each of the ITS runs in a quick and error-free manner. Except for the COMMON file, the rest of the project input data stay unchanged in the input data files, created off-line using the VAX/VMS editor. The input data files may be edited, when warranted by data changes.

In this document emphasis is on the use of Screen Data Editor for the purposes of data entry and interactively selecting run options for the COMMON input file to the GIANT portion of the ITS program. A step-by-step procedure for aerotriangulation (sec. V.C.) by ITS is given with the objective of walking the user through the process. Explanations of data fields, options, or list items are given in the HELP files (appendix B), which can be displayed on the screen. A brief mention is made of these aspects to assist the user in making the desired selection of run options for a successful aerotriangulation run using ITS.

II. OVERVIEW AND SETUP

There are three phases of data reduction in the analytical approach to the densification of control by aerotriangulation.

- Phase 1. Preprocessing. In this phase, measured plate coordinates of all the points are reduced to the plate coordinate system, centered at the principal point; and all known systematic errors, such as lens distortion, are removed.
- Phase 2. Aerotriangulation. In this phase, such programs as GIANT, accept preprocessed plate coordinates for all points, ground control coordinates, camera constants, and initial estimates of camera station position and attitude, for an iterative least squares solution to obtain camera station position and attitude angles, and ground coordinates for all pass points.
- Phase 3. Postprocessing.
- a. In this phase, camera station position and attitude are subsequently transformed into instrument settings, useful for model setup in a plotter for compilation purposes.
 - b. In this phase, the coordinates of the triangulated points are transformed from the geographic coordinates into the desired map projection using software such as GCTP/II.

The ITS program deals with phases 2 and 3 (b) given above, such that the system ultimately gives an aerotriangulation solution of camera station positions and attitude angles, and the ground coordinates for all pass points in the map projection selected from among the options available, provided all positional coordinates are first given in the geographic coordinate system.

III. DATA FLOW

Figure III.1 illustrates the data flow in ITS.

1. Input Data Files

Input data files for the program GIANT and ITS are identical. They consist of the following five files: COMMON, CAMERAS, IMAGES, FRAMES, and GROUND.

The description of each of these files is given in the GIANT User's Guide (Elassal and Malhotra 1987). The COMMON file in ITS is prepared interactively by means of the Screen Data Editor for full screen data entry. The rest of the files are created independently using the VAX/VMS editor.

2. Output Print Files

The output print files of ITS are as follows:

- o PRINT.OUT
- o SGIANT.OUT

The PRINT.OUT file gives the aerotriangulation results performed by the GIANT program and the SGIANT.OUT file gives the map projection coordinates of triangulated points computed by the GCTP program within ITS.

The GIANT program, integrated within the ITS program, performs analytical aerotriangulation and solves for the ground coordinates of points measured in

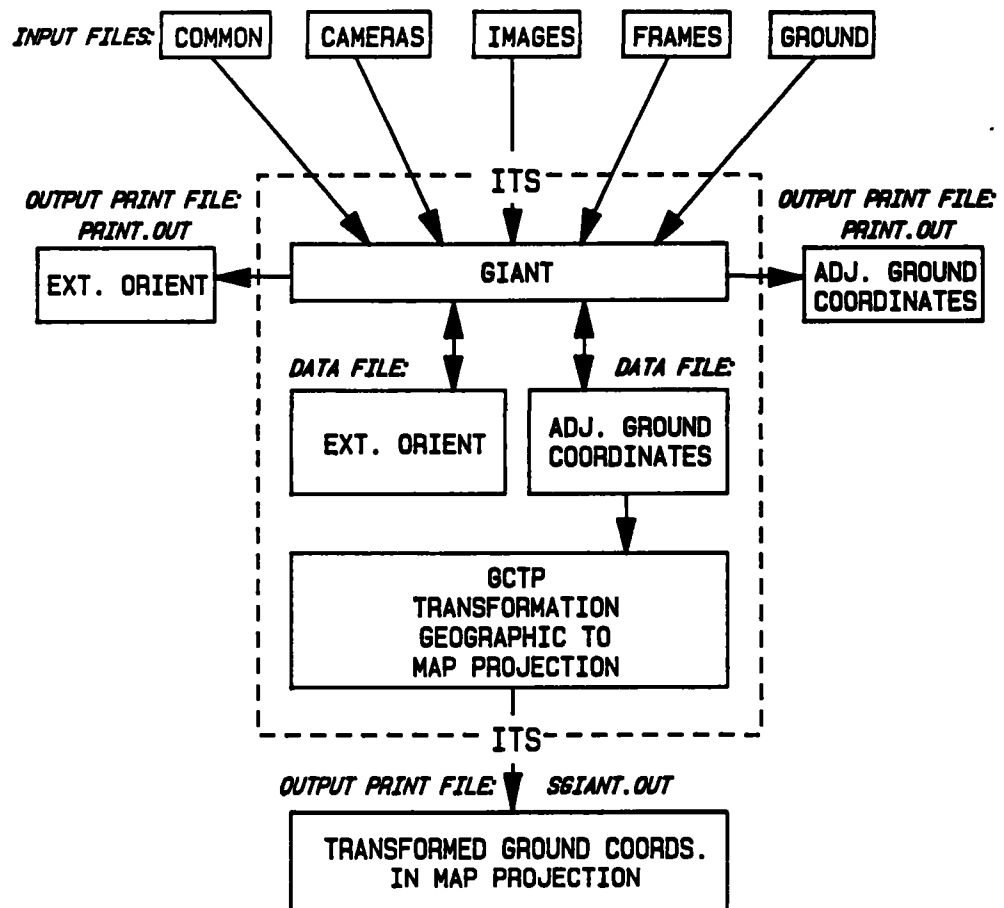


Figure III.1.--Data flow in ITS.

two or more photographs. It also determines camera position and its attitude at each of the camera stations. The program uses an iterative least squares technique for solving the parameters from a system of linearized collinearity condition equations, along with linear observation equations for the independently measured quantities, such as the ground coordinates of control points. The program accepts or assumes only uncorrelated observations. All observations are weighted according to the measurement precision. A complete listing of the files transferred as part of the GIANT package can be found in the file GIANT_FILES.DOC. A printout of the HELP files for the GIANT_SOURCE is obtained by the command:

```
PRINT GIANT_SOURCE:*.HELP
```

The GCTP program, integrated within ITS, determines the transformed map projection coordinates of the triangulated points from the GIANT portion of the ITS program. This program is utilized only when the input positional coordinates of the triangulated point are in the geographic coordinate system and the results are desired in one of the 20 map projections of the GCTP program.

IV. SCREEN DATA EDITOR

The Screen Data Editor allows data to be entered interactively for a data field at a specified location of the screen. Several data fields are displayed. Entries are selected from list items for some of the data fields, and for others entries are made and edited. HELP files for each of the data fields can be displayed as an aid to the selection of an appropriate option from the item list.

During the initial phase of the ITS program, data for the COMMON file for the GIANT portion of the programs are entered interactively using the Screen Data Editor. At the end of the GIANT run and during the execution of ITS program, the GCTP portion of the ITS program is entered into by answering 'Y' to the prompt:

DO YOU WANT TO TRANSFORM RESULTS TO MAP PROJECTION? [Y/N]

Obviously, the GCTP portion of the ITS is availed of only when using the geographic coordinate system as the object space coordinate system in the GIANT program. The space coordinates of the triangulated points are transformed into one of the 20 map projections of GCTP. The map projection selection and data entry are made interactively through the full screen data field display and the use of the Screen Data Editor.

The bottom row of the screen is reserved for messages. Range messages are displayed at the left of the screen and show the acceptable range of values for the data field being edited. If there is no range, the message RANGE UNLIMITED is displayed. If the data field contains text, the message ALPHANUMERIC FIELD is displayed. If the data field has an item list, the message ITEM LIST is displayed. Fatal error messages may appear while using the Screen Data Editor. If such an error occurs, the execution of the program terminates and an error message is displayed, indicating the conditions under which the error occurred. The error must be reported to the software maintenance personnel.

The Screen Data Editor accepts command options primarily from the keypad. Several options are displayed in a menu form on the screen. The menu displayed is the one showing the currently active options. It appears either at the top or at the bottom of the screen. Two menus are available at the main level and five menus at the secondary level. A secondary level menu appears only when an option selected from the main menu needs input.

A. Description of Menus

ITS contains the following main menus:

- o MAIN MENU: displays options for a data field that does not have an item list.
- o MAIN MENU (ITEM LIST): displays options for a data field having an item list.

ITS contains the following secondary menus:

- o PRINT DISPLAY options are available when key ",," from the keypad is entered from any menu.

- o LOCATE FIELD options are available when key "6" from the keypad is entered from either of the main menus.
- o CHANGING ENTIRE FIELD options are available when key "PF1" from the keypad is used from the main menu.
- o SEARCHING ITEM LIST options are available when key "9" from the keypad is used from the main (item list) menu.
- o VIEWING ITEM LIST options are available when key "_" from the keypad is used from the main (item list) menu.

B. Options Description

Each menu displays a number of options. An option consists of an option key and an option command text. Option keys are displayed brighter than the option command text, and specify a single key on the keypad or the keyboard. The User's Guide to Screen Data Editor gives details of the option keys, the corresponding text and action. The options are categorized as follows:

- o GENERAL OPTIONS are available from main and secondary menus.
- o DATA FIELD SELECTION OPTIONS select the data field to be edited and are available only from one of the main menus.
- o DISPLAY/MENU STATUS OPTIONS control the status of the display and menu, and are available only from one of the main menus.
- o MAIN MENU OPTIONS are exclusive to the main menu when the current field does not have an item list.
- o MAIN MENU (ITEM LIST) OPTIONS are exclusive to the MAIN MENU (ITEM LIST).
- o PRINT DISPLAY OPTIONS are exclusive to the print display menu.
- o LOCATE FIELD OPTIONS are exclusive to the locate field menu.
- o CHANGING ENTIRE FIELD OPTIONS are exclusive to the changing entire field menu.
- o SEARCHING ITEM LIST OPTIONS are exclusive to the searching item list menu.
- o VIEWING ITEM LIST OPTIONS are exclusive to the viewing item list menu.

C. On-Line Help Facility

An on-line help facility is available to programs which use the Screen Data Editor. When a request for help is made while editing a display, help text for the present data field is displayed. The help session can be ended by pressing ENTER on the keypad. Help text for the edit commands can be displayed by pressing CR (return). The general help text for the program or display can be displayed (if available) by pressing PF3 on the keypad.

D. Special Input Requests

Programs using the Screen Data Editor usually allow editing on all data fields within a display at the same time. This is referred to as the full-screen edit mode. Programs may request, however, a value for a specific field without allowing edits on the entire display. This is referred to as the one-field edit mode. If the data field contains an item list, the item list menu will be displayed. A new value should be selected from this list. If the data field does not contain an item list, the field for which a new value is being requested will flash and the "change entire value" menu will be displayed. A new value should be inputted.

E. Flow of Editing

The general flow of an edit session is to select a field, request help if not certain what data the field contains, and then enter a new value for the field if desired. To reset the display and all data fields to the values as they existed at the beginning of the edit session, press PF4 on the keypad. To obtain a file copy of the screen as it presently exists, press " ." on the keypad.

1. Selecting a field

There are two ways to select a data field as the field to be edited:

- o Press either the down arrow (next field) or the up arrow (previous field) until the desired field is shown in reverse video.
- o Press "6" on the keypad (locate field). Enter either the data or the label of the data field to be edited. To locate "Year", enter "Year" followed by a carriage return (be careful to enter "Year" and not "year" as upper case "Y" and lower case "y" are not considered the same).

2. Requesting help

If a data field is not defined by just the label or to obtain other help text as detailed under the HELP section, press PF2 on the keypad.

3. Entering a new value

There are several ways to enter a new value. It is important in entering data that ranges for values are heeded, signs (+ or -) are entered either as the first character in a field or replace an existing sign, and only digits or signs are entered for numeric data fields.

- o When entering values for data fields which do not contain an item list replace only the offending characters. To change the year from 1986 to 1976, use the right arrow (next character) and left arrow (previous character) to position the cursor on the "8" and enter "7" (remember that data is entered from keyboard, only options are selected from the keypad). Replace the entire value. Press PF1 (changing entire field) and enter "1976" followed by a carriage return.

- o When entering values for data fields which do contain an item list go through the item list a value at a time. To change the month to April, press 7 on the keypad (previous list item) or 8 on the keypad (next list item) until April appears in the data field.

V. TRIANGULATION PROCEDURE

The ITS consists of two parts, GIANT and GCTP.

The input data to ITS are identical to the input data for the GIANT program. The data are processed to obtain a least squares solution to the general triangulation problem, which gives space coordinates of triangulated points in either the geographic or a rectangular coordinate system, depending on the input data. In case the output from the GIANT portion of the ITS is in the geographic coordinate system, there is an option for the user to transform these coordinates to any of 20 map projections available in the GCTP portion of ITS.

A. User Directory

The GIANT command procedure is designed such that the GIANT source and the GIANT source data files are stored in one directory, GIANT_SOURCE, and executed from any number of other user directories. The user copies the GIANT input definition command file, DEFINE_GIANT.COM, to the directory under which GIANT is to be executed:

```
$ COPY GIANT_SOURCE:DEFINE_GIANT.COM []
```

(Note: The user directory will contain the temporary and the output files created by GIANT. It should not contain files with names: *.DAT, *.FDL, *., as these files will be deleted.)

The user must edit the input definition command file in the user directory by entering the command:

```
$ EDIT DEFINE_GIANT.COM
```

The screen displays the input definition command file in the user directory:

```
$ DEFINE/NOLOG GCAMERA.IN      GIANT_SOURCE:CAMERA.IN
$ DEFINE/NOLOG GFRAMES.IN      GIANT_SOURCE:FRAMES.IN
$ DEFINE/NOLOG GIMAGES.IN      GIANT_SOURCE:IMAGES.IN
$ DEFINE/NOLOG GGROUND.IN      GIANT_SOURCE:GROUND.IN
```

The file names in the GIANT_SOURCE directory, as given above, are replaced by the names of the files created in the user directory; e.g., input data file GIANT_SOURCE:CAMERA.IN in the input definition command file of the user directory is replaced by TRIANG_PROJ.CAMERA, which is an example of a file containing camera constants created by the user in the user directory.

B. Input Data Files

The input data files for the program ITS are exactly the same as for the program GIANT, with the only difference that the file COMMON is created

interactively using the Screen Data Editor (sec. III). Also, at the end of the first phase of the program, which solves for the coordinates of the triangulated points and camera parameters, the program ITS gets into the second phase of coordinate transformation using the program GCTP.

Before executing the program ITS, the user creates the input data files: CAMERAS, IMAGES, FRAMES, and GROUND according to the instructions and format given in the GIANT User's Guide. At the end of execution of the first phase of triangulation, the user gets into the second phase of ITS by responding to the query:

DO YOU WANT TO TRANSFORM RESULTS TO MAP PROJECTION ? [Y/N]

The Y response is made only when the output from the first phase of ITS is in geographic coordinates. A full screen display appears for the user to define the OUTPUT SYSTEM, which can be chosen interactively from 20 different map projections by flipping through the item list for the name field of the map projection. Once the map projection is selected, the rest of the information pertaining to the map projection is inputted through the screen using the Screen Data Editor.

C. Step-by-Step Instructions for Triangulation and Coordinate Transformation

Triangulation project by the program ITS consists of the following steps:

PHASE I - TRIANGULATION

1. Create input data files: CAMERAS, IMAGES, FRAMES, and GROUND in the user directory, according to the input data files given in the GIANT User's Guide.
2. Execute program GIANT within ITS by entering the following command:

```
$ GIANT
```

In case the input definition file DEFINE_GIANT.COM is not found in the user directory, then the following prompt appears:

```
Abort : file DEFINE_GIANT.COM not found.
```

A message follows for the format and use of the COPY command. Enter the following command in order to copy the DEFINE_GIANT.COM file in the user directory under which GIANT is to be executed:

```
$ COPY GIANT_SOURCE:DEFINE_GIANT.COM []
```

(Note: Program GIANT creates and uses temporary files. These files will be deleted at the end of execution by deleting all files of the type: *.DAT;*, *.FDL;*, and *.*;*. For this reason, there should not be files of these type in the user directory from which the GIANT is to be executed.)

3. Review/edit the input definition file DEFINE_GIANT.COM in the user directory, under which GIANT is to be executed, to verify that the input data files are defined correctly. Enter command:

\$ EDIT DEFINE_GIANT.COM

The screen displays the command file:

```
$ DEFINE/NOLOG GCAMERA.IN  GIANT_SOURCE:CAMERA.IN
$ DEFINE/NOLOG GFRAMES.IN  GIANT_SOURCE:FRAMES.IN
$ DEFINE/NOLOG GIMAGES.IN  GIANT_SOURCE:IMAGES.IN
$ DEFINE/NOLOG GGROUND.IN  GIANT_SOURCE:GROUND.IN
```

The file names in the GIANT_SOURCE directory, as displayed, are replaced by the names of the input data files created in the user directory.

Example: Replace GIANT_SOURCE:CAMERA.IN by the user file: e.g.,
TRIANG_PROJECT:CAMERA (in the user directory) during
the editing process.

4. Enter GIANT to execute the program ITS:

\$ GIANT

5. Respond to the prompt on the screen:

USE UPDATED ORIENTATION PARAMETERS? [Y/N]

(Note: This prompt does not appear in the first iteration of the execution of the program GIANT).

Y response will use the updated parameters from the previous run. The updated parameters are that of the camera position and attitude for all exposures, stored in output file Logical ID no. 20, which is always created whether the triangulation solution converges or not. For details see Giant User's Guide (Elassal and Malhotra 1987: 49).

N response will not use the updated parameters, but will use the approximations to the camera position and attitude for all exposures from file FRAMES created by the user initially.

6. Respond to the prompt on the screen:

DO YOU WANT TO RUN REORDER ? [Y/N]
DO YOU WISH TO SET GIANT PARAMETERS TO DEFAULT VALUES? [Y/N]

(Note: The second query will not appear in the first iteration of GIANT).

Y response to the first query will reorder the sequence of photographs in the block adjustment in order to minimize the bandwidth of the normal matrix in the normal equations of the least squares solution.

Y response to the second query will set GIANT parameters to default values, otherwise these will take up values from the previous iteration.

7. Interactively enter the run options for aerotriangulation on the full data screen display entitled: GIANT TRIANGULATION (See table V.1.)

See appendix B, Main Help File, for GIANT AEROTRIANGULATION.

8. Accept the screen entries by command ' 1 ' on the keypad.

The run options selected for the run are displayed on the screen, and the GIANT portion of the ITS program starts executing.

Table V.1.--Example screen display of data fields

```

!-----26-AUG-88-----GIANT14:18:55-----STK-----!
AEROTRIANGULATION SYSTEM
Job Title: CMB606 LAKE MICHIGAN
Object Space Definition Geographic Rotation Angles Photo-to-Ground
UNITS OF MEASURE: Planimetric DMS Elevation Feet
INPUT LISTING OPTIONS: OUTPUT LISTING OPTIONS:
Camera Stations YES Camera Stations YES File Results? YES
Image Points YES Ground Points YES
Ground Control YES Sort Points YES
Operational Mode TRIANGULATION
Error Propagation YES
Statistical Mode Free Camera Stations
Name_Fields Adjustment Character 0 Solution Conversion Criterion 5
Image Residuals Listing Criterion 0 Number of Iterations 9
Datum NAD 83
Type of Refraction atmosphere and water Water Level 0.00 Feet
DEFAULT STANDARD DEVIATIONS OF CONTROLS:
LONG 0.035 DMS LAT 0.025 DMS ELEV 6.560 Feet
-----

```

Table V.1 shows a typical screen display of the data fields. Input to the data fields having list items can be selected from the list items available.

The on-line help facility for the data fields gives a detailed description of each of the data fields and their list items. This enables the user to make a judicious data entry. The help text is displayed by using the PF2 key on the keypad of the terminal.

(Note: The main help text for the GIANT program and for each of the data fields in the full screen display GIANT TRIANGULATION is given in appendix B.)

PHASE II - COORDINATE TRANSFORMATION

In case the object space coordinate system is NOT the geographic coordinate system, the program skips step numbers 9 through 13 and the user responds to the prompt on screen for step number 14, otherwise:

9. Respond to the prompt, which appears as soon as the GIANT portion of the ITS program is executed:

DO YOU WANT TO TRANSFORM RESULTS TO MAP PROJECTION? [Y/N]

(Note: This prompt appears only if the object coordinate system is the geographic coordinate system.)

Y response transforms geographic point coordinates to coordinates in any one of the 20 map projections available in the program GCTP.

Also, respond to:

DO YOU WISH TO SET TRANSFORMATION PARAMETERS TO DEFAULT VALUES? [Y/N]

(Note: Once the selection of output reference system is made from the item list for the data field for REFERENCE SYSTEM, data entry is done through a full screen display of data fields related to the map projection so selected.)

10. Select the output reference system from the item list for the REFERENCE SYSTEM data field in the full screen display for OUTPUT SYSTEM DEFINITION.

11. Enter data interactively for the data fields corresponding to the reference system selected, using the full screen display and the Screen Data Editor.

12. Accept the data for the full screen displaying output system definition parameters.

13. Respond to the prompt on screen:

DO YOU WANT TO SEE MAP PROJECTION RESULTS ? [Y/N]

Y response displays the transformed coordinates in the selected map projection. These transformed coordinates are also recorded on the output print file SGIANT.OUT.

14. Respond to the prompt on screen:

DO YOU WISH TO SEE GIANT OUTPUT ? [Y/N]

Y response displays the GIANT output on screen, which is also on the output print file PRINT.OUT.

D. Output Print and Data Files

After having gone through the above steps, output print files PRINT.OUT and SGIANT.OUT can be printed out using commands:

```
$PRINT PRINT.OUT      ...GIANT results
$PRINT SGIANT.OUT     ...Map Projections results
```

The PRINT.OUT file contains aerotriangulation results from the GIANT portion of the program ITS; whereas SGIANT.OUT contains the map projection output from the GCTP portion of the program ITS. Also, GIANT internally creates and uses some unformatted data files which will not be deleted but will be reused; these files are:

```
GGIANT.TEMP      ...updated orientation parameters
GIANTP.SAV       ...GIANT parameters last used
GIANTG.SAV       ...transformation parameters last used
```

The file GGIANT.TEMP is used as the input file for succeeding iterations, if so opted (step number 5 above), in lieu of the input files FRAMES and GROUND. The files GIANTP.SAV and GIANTG.SAV are files used to initialize the screens with parameter values last used.

The geographic coordinates of the triangulated points from GIANT, the first phase of ITS, are passed on to the next phase, which is coordinate transformation, performed by the GCTP within the program ITS.

VI. DATA EDITING AND RUN STRATEGIES

The flexibility which makes ITS useful also makes it difficult to establish a unique procedure for data editing and analysis. Each project may have to be tackled differently. However, there are some general guidelines or run strategies which could be followed to optimize the solution. Analysis of the project data for aerotriangulation usually takes several runs before a final solution is reached.

A. Data Editing

1. Data editing in the initial few runs

In the initial few runs of ITS, option INTERSECTION is selected from the available options INTERSECTION/TRIANGULATION for the aerotriangulation phase by GIANT within ITS. An intersection-only allows identification and removal of the following gross errors:

- o Very large errors in plate coordinates or misidentification;
- o Incorrect combination of photograph numbers and associated points;
- o Consistently bad photographs, due to a blunder in the camera station parameters; and
- o Blunders in ground control coordinates, which are proofread.

Since this run is made with initial approximations only, large plate residuals in a certain pattern should be expected. Then one must look for a break in the pattern. In the initial runs, transformation of coordinates from geographic to any one of the 20 available map projections in GCTP is not necessary, rather it is carried out in the final run of the analysis.

In case, upon examination of an initial run, the computed elevation of a ground control point is higher than the camera station position, one of the two most probable blunders occurred:

- o Sign of f : The sign of the focal length is incorrectly entered.

(Note: If the plate coordinate data as preprocessed should construct a photo positive, the sign of the focal length is negative, otherwise positive.)

- o Yaw: The yaw angle is incorrect.

(Note: This may be checked by plotting several points from a photo positive on a map and rechecking the relationship of image space ' y ' and north.

2. Data editing by the study of plate residuals

Major blunders are relatively easy to identify and rectify in plate coordinate data. Difficulty occurs when gross errors are eliminated and a judgment must be made to eliminate points which introduce large errors in the solution. Also, elimination of a point from the solution may weaken the geometry of determination of coordinates. There are no clear-cut rules on the matter of elimination of points.

Listed below are some residual patterns which must occur as one approaches the optimum solution. These trends are not obvious to the casual user and therefore must be carefully examined during the analysis of aerotriangulation runs by ITS.

- a. Residuals will group by the number of photographs (rays) seeing a point. The residuals will appear larger for those points seen by more rays.
- b. Residuals in the direction of flight tend to become zero. This is especially true for two-ray points. In such cases, the elevation of the computed ground position should be watched along with the plate residuals.
- c. Ground control will tend to show a different residual grouping than for uncontrolled points. This tendency is directly related to the weighting of the plate coordinates and the control point coordinates.
- d. The residuals should balance for all points, i.e., the positive and negative residuals should add up to zero. This will be approximate, but generally true for a well-adjusted run.
- e. There should not be any discernable pattern of errors, i.e., no systematic component. In other words, the residuals should conform with the laws of normal distribution:
 - o Small errors are more likely than large errors;
 - o Positive and negative errors are equally likely; and
 - o Zero error is the most probable error.

3. Editing by the study of camera parameters

When editing an aerotriangulation computer run with unconstrained camera stations, the camera stations are only reflecting the influence of other data: the plate coordinates and the ground control.

On each run one should examine the camera positions and orientations, and ensure they are following a consistent path. Any deviation from the basic two rules of thumb should be explained and corrective measures taken:

- o Mapping photography is flown straight and level as far as possible; and
- o Aircraft never flies exactly straight and level.

4. Editing by the study of ground control

There are three possible causes of errors in aerotriangulation runs due to ground control points:

- a. Misidentification of the control
- b. Poor point transfer
- c. Bad coordinates of the point

Remedial action is determined by the cause. Use the following options for remedial action:

- a. Downgrading the "type" of point, e.g., from fully known to horizontal only, provided the elevation component is bad.
- b. Increasing the associated standard deviations to reflect the point is not as well known as others.
- c. Changing the "type" of point, e.g., from control to a pass point.
- d. Removing or rereading bad plate coordinates.

There are two groups of ground control points defined by the analyst. They are referred to as HELD and UNHELD ground control points.

- a. The UNHELD ground control points consist of all the ground control points. All their coordinate values are included in the UNHELD group. These values are not included in the solution. They in no way affect the answers derived by the program. They do let the user keep track of all the points, whether good or bad, and evaluate how changes in the program run affect the residuals at the control points.
- b. The HELD ground control group consists of control points and coordinates used in the adjustment. These affect the solution and must be closely analyzed for control residuals.

5. Data editing using key numbers in ITS

The following key numbers must be watched carefully when executing the GIANT portion of ITS:

- a. A posteriori estimate of variance of unit weight

This is an important single number by which to judge a run. For a "normal" case this number should approach one (1.0). The number starts out very large, and as the data editing and bootstrapping improve the data, it comes down to a reasonable value. It must be remembered, this number only reflects the balance between the input standard deviations and the output residual. If for some reason the weighting is not realistic, this number may not approach one (1.0). Watch it carefully as an indicator of overall performance along with the contributing component of the number.

b. Weighted sum of the squares

This number along with the changes in camera station parameters is printed for each iteration. It can be used to judge how much each iteration is changing the solution and to some extent, where the change is occurring. This number is an estimate of the sum of the squares of the plate residuals. It is used as a convergence test; i.e., when this number changes less than a predetermined percentage the solution is stable and iterations stop. This number is most often huge at the beginning. If the number increases between iterations, the run has "diverged" usually because of bad data or weak geometry, and is incapable of coming to a good solution. Edit the data or submit with fewer iterations and then edit.

c. Number of iterations

The default value for this input can be overridden by entering a number in the NUMBER OF ITERATIONS field in the aerotriangulation screen display. Usually four is a good number for most runs. The actual number of iterations (to compute corrections and update the values of the solvable parameters for bootstrapping the solution) could be less than or greater than this number. The run may cut off before reaching the maximum number of iterations based on the criterion of percentage change in the value of the weighted sum of the squares for a solution in the current iteration compared to its value in the previous iteration. The reason for having this number variable is that in some cases one may want to perform a minimum amount of adjustment so blunders can be isolated from the solution. In other cases one may want the run to last longer and obtain the best solution.

d. Weight matrix

The weight matrix is the inverse of the input variance-covariance matrix. This is composed of the input standard deviations for all measurements. It is possible to "warp" the solution in any manner one desires by manipulating the weights. The best available guide is to weight realistically. For example, if the control is scaled from 1:24,000 map, make the weights appropriate to the accuracy of the equipment, personnel and measurement procedure based on the job requirements. Five to 15 micrometers is the normal range of standard deviations assigned to the input measurement data. In the extreme case, this value can be as low as 3 micrometers, when using the best possible photogrammetric system: camera, film, measurement equipment, care, and procedure for data reduction.

Invariably a time comes when one is faced with insufficient information regarding the input standard deviations and hence lack of information in the formation of the weight matrix. At other times, things do not seem to be working right during the adjustment process. These are the times weights are changed by:

- o Locking the control, using small values of standard deviation for control coordinates;
- o Loosening the camera position, using large values of standard deviations for the camera position coordinates; and

- o Tightening the camera orientation parameters, using small values of standard deviations of the parameters.

Any combination of the above changes can be manipulated until one achieves the desired results. These are legitimate data editing techniques, carried out deliberately in the absence of sufficient information. However, if possible, the weights are changed back to realistic values after the data editing process.

B. Run Strategies

Multiple runs will be required to produce the best solution in an aerotriangulation project. The objectives of these runs are listed below. One run may achieve one or more objectives, or multiple runs may be required for an objective, depending on the size and number of blunders in the data.

1. Edit blunder

The first run should be with the INTERSECTION ONLY option in the aerotriangulation screen display. This option overrides the normal solution and allows the program to go through all the motions, taking only the initial approximations, and computing plate residuals and ground coordinates. No adjustment is performed. This is extremely useful for the first run for eliminating large blunders before they distort an adjustment beyond recognition.

2. Clean up plate coordinates

The second objective in the AEROTRIANGULATION run should be to tie the plates together, i.e., to achieve consistent and low plate coordinate residuals. This can be achieved with little or no control and the camera station parameters relatively "loose", i.e., free to adjust. If there are many problems, it may be necessary to constrain the camera station parameters more tightly to prevent them from over-reacting to the errors. It may also be desirable to cut the number of iterations to one or two.

3. Fit the control

The objective now is the twofold requirement of improving camera station position and orientation, and fitting the aerotriangulated points to the ground control, wherever known. A run is made with only those ground control points which seem to fit or show systematic discrepancies from the preliminary runs. If the solution shows marked improvement, it may be desirable to save the camera station parameters and substitute these for their previous initial approximations for the next run. This is often called "bootstrapping." Weights are not tightened, i.e., the values of the input standard deviations are not lowered, because no new information has been received, nor are the parameters known any better.

4. Error propagation

The last run should include the error propagation option entered through the aerotriangulation screen display using the screen editor. In terms of computer time, this is an expensive option to exercise and does not yield much information in the initial phases. The output shows the spread of accuracies of the triangulated points and the camera station parameters.

5. Bandwidth error

Bandwidth errors are the result of a point appearing on photographs beyond the program limit. The first and the last appearance of a point may not exceed a certain number (program limit) of photographs. The most common cause of this error is duplication of a point number, inadvertently on separate sets of photographs. If this message appears during a run, or other unexplained adverse results occur, then the job must be rerun with the INTERSECTION ONLY option. An error message identifying the point will probably help in isolating the problem.

6. Adding points after job completion

A common occurrence is to finish a triangulation project and, after a day, week, month, or years later, receive a request for additional point coordinates from the same project. This may be accomplished easily by saving the last set of camera station parameters and setting up an INTERSECTION only run. The new points are marked, measured, and preprocessed as were the points used in the adjustment before, and then either added to the appropriate frames or run in the program by themselves preferably with some other points previously determined for a check. If this is done, the solution will not be affected and a consistent set of coordinates will be produced.

REFERENCES

- Elassal, Atef A., and Malhotra, Roop C., 1987: General integrated analytical triangulation (GIANT) user's guide. NOAA Technical Report NOS 126 CGS 11, 66 pp. National Oceanic and Atmospheric Administration, N/CG174, Rockville, MD 20852.
- Elassal, Atef A., 1987: General cartographic transformation package (GCTP), version II. NOAA Technical Report NOS 124 CGS 9, 24 pp. National Oceanic and Atmospheric Administration, N/CG174, Rockville, MD 20852.

APPENDIX A.--REFERENCE SYSTEMS SUPPORTED BY GCTP/II

The GCTP/II supports transformations between any two of 21 two-dimensional reference systems. Each reference system is identified in the package by a code number (0 through 20). The following reference systems are supported by

<u>Code Number</u>	<u>Reference Name</u>
0	Geographic (longitude and latitude)
1	Universal Transverse Mercator (UTM)
2	State Plane
3	Albers Conical Equal-Area
4	Lambert Conformal Conic
5	Mercator
6	Polar Stereographic
7	Polyconic
8	Equidistant Conic
9	Transverse Mercator
10	Stereographic
11	Lambert Azimuthal Equidistant
12	Azimuthal Equidistant
13	Gnomonic
14	Orthographic
15	General Vertical Near-Side Perspective
16	Sinusoidal
17	Equirectangular
18	Miller Cylindrical
19	Van Der Grinten I
20	Oblique Mercator (Hotine)

APPENDIX B.--HELP TEXT FILES (GIANT AEROTRIANGULATION SYSTEM)

GENERAL HELP FILE

General Description

General Integrated ANalytical Triangulation (GIANT) is a computer program designed to perform analytical triangulation to solve for the ground coordinates of image points measured on two or more photographs. The parameters solved in this program are the ground coordinates of each of the image points, as stated above, and the parameters of each camera station position and orientation.

The program uses an iterative least squares technique. It accepts or assumes only uncorrelated observations. All parameters and observations may be weighted to reflect a prior knowledge of their precision. This is particularly useful in weighting ground control differentially, compensating for different sources of control of varying precision, as well as being able to utilize control with unknown components. This allows the use of partial control points of which any horizontal and vertical component is known with varying accuracies. The user may enforce known camera station positions and orientations if they are determined by external source, such as a navigation device on the aircraft. When these parameters can be enforced as observed quantities, the need for ground control is significantly lessened for comparable accuracy.

The program also propagates error estimates through the solution, computes the 'a posteriori' estimate of variance of unit weight, and on option, the variance-covariance matrix and standard deviation of each parameter of each camera station position and orientation, and ground coordinates. When used with a fictitious data generator, a user may predict results before using a set of photography, a given control pattern, or other variables. Accuracy could be predicted and additional or different configurations of control planned.

The iterative least squares approach requires an initial approximation for each unknown parameter. The program has proven to accept reasonably gross approximations for these parameters.

The program expects object space coordinates to be in a space rectangular or in a spherical/geographic coordinate system. A rectangular coordinate system is generally required for close range photogrammetry and the spherical/geographic system for mapping projects. The camera attitudes are parameterized in terms of roll, pitch, and yaw (omega, phi, kappa) referenced to the local vertical, and may express the relation between image and object coordinate spaces.

Program Capabilities and Restrictions

The GIANT program employs an highly efficient algorithm for the formation, solution, and inversion of large linear systems of equations. An agency will have to determine the maximum size of a project it will ever handle in order to define the following parameters during installation of the program. The following parameters are defined for a particular version of the program installed:

- o Maximum number of camera stations.....N1(0400)

- o Maximum number of ground point (includes all points of which ground coordinates are computed).....N2(2000)
- o Maximum number of control points (< or = N2).....N3(0500)
- o Maximum number of frames in which a unique point appears.....N4(0025)
- o Maximum number of camera systems.....N5(0010)
- o Normal equations bandwidth.....N6(0020)

Due to the virtual memory available in computers, the size of the project that can be handled is almost unlimited. Other program capabilities include:

- o Object space can be expressed in a space rectangular or in a spherical/geographic coordinate system.
- o Camera attitudes are parameterized in terms of roll, pitch, and yaw (omega, phi, kappa) and may express the relation between image and object coordinate spaces.
- o Camera station position and attitude parameters can be constrained in any desired fashion. Also, full or partial ground control can be utilized.
- o Photography from any number of camera systems may be triangulated simultaneously.
- o Data entry is grouped by photographs with the program performing all necessary cross-referencing and pass point ground coordinate estimates.
- o Complete error propagation facility exists for detailed statistical assessment of the triangulation results.
- o A facility exists for sorting the triangulation results.
- o Corrections applied to ground coordinates as a result of the triangulation are listed for reference.
- o The internal defaults for estimated standard deviations can be declared on an additional record. Provision still exists for declaration for individual data items.
- o The unit variance of the triangulation residuals is listed.
- o Ground control corrections, when input is geographic, are shown in both geographic and local space rectangular units.
- o Camera station corrections for each iteration are shown in local space rectangular units.
- o Control points can be designated as 'UNHELD' and used as test points. The residuals are listed separately and a separate RMS computed.
- o Run time errors detected during the input phase (due to illegal format or

data types) are printed showing the record number and contents of the offending record.

MAIN HELP FILE

(Reference table V.1)

SCREEN DISPLAY:

DATA FIELD

HELP TEXT (EXPLANATION OF DATA FIELD)

- Job Title..... This title field can contain up to 55 printable characters. GIANT will append time and date of run to this field. The resulting 80 character field will be reproduced at the top of each page of GIANT's printout.
- Object Space Def... This field defines the type of OBJECT reference system. Ground control coordinates and camera exterior orientation are expressed in OBJECT reference system. It is recommended to use GEOGRAPHIC reference system for standard mapping, and RECTANGULAR reference for special applications, such as close range photogrammetry.
- Rotation Angles.... This field states the type of relationship that is defined by the attitude portion of the camera exterior orientation. For VERTICAL photography, estimates of pitch and yaw of camera stations are normally given as zeros. The heading part is estimated as follows:
- PHOTO-TO-GROUND rotation angle: heading is clockwise angle measured from OBJECT space easting to CAMERA x-coordinate.
- GROUND-TO-PHOTO rotation angle: heading is anticlock-wise measured from OBJECT space easting to CAMERA x-coordinate.
- UNITS OF MEASURE:
- Planimetry..... Units of measure in OBJECT space: Longitude and Latitude for GEOGRAPHIC reference system; easting and northing (X,Y) for RECTANGULAR reference system.
- ANGULAR units of measure:
- o DMS: Degrees-Minutes-Seconds in format DDDMMSS.SSS...
 - o Radians: Radians and decimal radians.
 - o Degrees: Degrees and decimal degrees.
 - o Seconds: Seconds and decimal seconds.
- LINEAR units of measure:
- o Meters: Meters and decimeters (Int'l)
 - o Feet: Feet and decimal feet (American)
- Elevation..... Units of measure in OBJECT space:
- o Meters: Meters and decimeters (Int'l)
 - o Feet: Feet and decimal feet (American)

INPUT LISTING OPTIONS:

Camera Stations.... LIST/NOLIST option for INPUT camera stations exterior orientation parameters.

Image Points..... LIST/NOLIST option for INPUT photo image points.

Ground Control..... LIST/NOLIST option for INPUT ground control points.

OUTPUT LISTING OPTIONS:

Camera Stations.... LIST/NOLIST option for OUTPUT camera stations exterior orientation parameters.

Ground Points..... LIST/NOLIST option for OUTPUT ground control points.

Sort Points..... SORT/NOSORT option for OUTPUT triangulated ground points.

File Results..... SAVE/NOSAVE of OUTPUT camera station exterior orientations in a DATA-FILE. This DATA-FILE could be used to RESTART a new set of least squares iterations.

Operational Mode... TRIANGULATION-perform least squares adjustment (gives new camera orientation parameters). OR
INTERSECTION-perform intersection only (no changes to camera orientation parameters).

Error Propagation.. PERFORMANCE/NONPERFORMANCE of error propagation function.

Statistical Mode... Statistical mode for error propagation:
FREE CAMERA STATIONS/CONSTRAINED CAMERA STATIONS modes affect the inclusion or exclusion of camera station exterior orientation parameters in the COUNT of number of degrees-of-freedom for the least squares adjustment. A POSTERIORI VARIANCE IGNORED mode will result in no adjustment to computed covariance matrices for a Posteriori Estimate of Unit Variance. This mode should be used only for error propagation studies.

Name-Fields Adj.

Character..... Leading characters in all name fields (camera, photo, image and ground identifications), will be deleted by GIANT if they match the specified character in this field. (For example, if this field is specified as zero '0', then GIANT will consider the name fields 1203, 01203, 001203, the same.)

Solution Convergence

Criterion..... The integer number specified in this field will be interpreted as a percentage. GIANT will consider least squares solution converged when change in weighted sum of squares for two consecutive iterations is less than the specified percentage.

DATA FIELD

HELP TEXT (EXPLANATION OF DATA FIELD)

Image Residuals

Listing Criterion.. The integer in this field is the number of micrometers, and will affect the LISTING of image residuals as follows:
Number > 0 : Image residuals greater than the integer entered are listed.
Number = 0 : Image residuals for all points are listed.
Number < 0 : No image residuals are listed.

Number of Iter..... GIANT will perform number of iterations > or = to the integer specified for this field. If the value of this field is < or 0, then GIANT will use the default value of 4.

Reference

Spheroid..... NAD 27/NAD 83/unknown reference spheroid for OBJECT space geographic reference system.

Type of

Refraction..... ATMOSPHERE/ATMOSPHERE AND WATER/NONE: This field controls the application of Atmospheric Refraction correction to image coordinates--either Atmosphere/Atmosphere and Water/None. The current Refraction Mathematical Model for Atmospheric Refraction is ONLY applicable up to the 9,000 meters flight altitude. Imagery flown at higher altitudes should be corrected for refraction prior to GIANT run.

Water Refraction is the correction to overhead imagery of underwater features. This option should be exercised only by those who have photobathymetry capabilities.

Water Level..... Water level for underwater refraction correction option is expressed in the given units.

DEFAULT STANDARD

DEVIATION OF CONTROL:

LONG (DMS)..... Default values for standard deviation of coordinates of control points. This field is interpreted to have the same units of measure as defined for OBJECT space refraction system.

LAT (DMS)..... Default values for standard deviation of coordinates of control points. This field is interpreted to have the same units of measure as defined for OBJECT space refraction system.

ELEVATION

(FEET/METERS)..... No HELP TEXT for this field.

APPENDIX C.--SCREEN DATA EDITOR USER'S GUIDE

The Screen Data Editor is a program independent data display and entry package which allows data to be displayed and entered at specific screen locations as opposed to the query-response format. Several items may be displayed, edited and accepted at the same time, or special input requests may require the entry of a single item.

DEFINITION OF TERMS

- o A DISPLAY is a collection of information (data fields, labels, lines, etc.) which is placed on or removed from the screen as a single unit. There may be more than one display on the screen at the same time.
- o A DATA FIELD is an area of a display in which a value is shown.
- o An ITEM LIST is a list of possible values for a given data field. If a data field has an item list, a value for the data field must be selected from the item list.
- o CR refers to the Return Key (carriage return).

DISPLAY CONVENTIONS

- o The display being edited is bordered by a dull line (if there is room on the screen). Lines separating data may appear on the screen but these will be brighter in intensity than lines for the display border.
- o The name of the display, if present, will appear centered at the top of the display and set inside a long bright rectangular box as in:

DISPLAY TITLE

- o Labels are underlined.
- o Data fields which cannot be edited are displayed in bright text.
- o The data field currently being edited appears highlighted in reverse video.
- o The date, time, and user's name may appear on one or more displayS; this information will usually be displayed along the border of the display title with the time being continuously updated.

MESSAGES

The screen editor displays messages in three areas:

- o Range messages are displayed at the left in the last row of the screen and show the acceptable range of values for the data field presently being edited. If there is no range the message "range unlimited" is displayed. If the data field contains text the message "alphanumeric

field" is displayed. If the data field has an item list, the message "item list" is displayed.

- o Error messages are displayed in bright letters and appears at the right in the last row of the screen. Error messages could possibly overlap portions of the range message. The error message will be removed when the next key is pressed.
- o Some error messages may require verification before allowing the program to continue. These errors will temporarily clear the screen; display the message in the center of the screen and wait for a key to be pressed to continue processing.

Fatal error messages may occur while using the screen data editor. A fatal error is one which terminates execution of a program. If such an error should occur, carefully note the complete error message and the conditions under which the error occurred (the name of the program, the function being performed, etc.) and report the error to software maintenance personnel.

Programs using the screen data editor may access any of these message areas (in this case the range message area is used for general information or instructions) or they may create other message areas for information, instructions, warnings, and errors. The general help file for the individual program should provide assistance when messages are not obvious.

MENUS

The screen editor accepts command options primarily from the keypad. Options are displayed by one of seven menus. The menu displayed is the one showing the currently active options and is displayed either at the top of the screen or at the bottom of the screen. Note that the menu may cover part of the display though not necessarily data fields. If this occurs, the message "display continued beneath menu" is shown at the top right of the menu.

There are two menus at the main menu level and five menus at the secondary level. A secondary level menu is displayed when an option selected from the main menu needs more input.

The main menus are:

- o MAIN MENU - Displays options for a data field that does not have an item list.
- o MAIN MENU/ITEM LIST - Displays options for an item list data field.

The secondary menus are:

- o PRINT DISPLAY - Options for printing the display.
- o LOCATE FIELD - Options for locating a field.
- o CHANGING ENTIRE FIELD - Options for entering a new value for a field.

- o SEARCHING ITEM LIST - Options for searching an item list to find a specific value.
- o VIEWING ITEM LIST - Options for selecting a value from an item list by viewing the list.

Programs using the screen data editor may create their own program dependent menus and assign functions to various keys which are different from the uses described for the screen data editor (the keys for "help," "abort," and "print display" should remain constant). These menus should be displayed only when the screen data editor is not active. The general help file for the individual program should provide assistance for using these program dependent menus.

OPTIONS

Each menu displays a number of command options. An option consists of an option key and option command text. Option keys are displayed brighter than the option command text and specify a single key on the keypad or keyboard; the same convention should hold true for program dependent menus as well.

General Options

General options are available from main and secondary menus.

- o key: PF2 (keypad)
text: Help
action: Displays help text for the data field presently being edited and can also display help text for the screen data editor commands or general help text for the program or display. (See HELP for more information.)
- o key: . (keypad)
text: Print display
action: Sends the display to a file which may be printed at a later time. Any file can be specified provided it is a new version. (See Print Options for more information.)
- o key: Tab
text: Abort
action: Aborts the current program. Should only be used when standard termination procedures are undesirable or not available. (It may be necessary to press the tab key twice.)

Special Functions Option

The special function option controls access to program dependent functions available through the screen data editor and is available only from one of the main menus for some programs. The "text" and "action" are program dependent and, if available, should appear somewhere on the screen as a label or a menu item. (See also Accepting and Resetting Display.)

- o key: PF3
text: (Program Dependent)
action: (Program Dependent)

Data Field Selection Options

Data field selection options select the data field to be edited and are available only from one of the main menus.

- o key: Up arrow
text: Previous field
action: Moves cursor from the present field to the previous field on the display. However, if a value out of range was entered, no action is taken.
- o key: Down arrow
text: Next field
action: Moves cursor from the present field to the next field on the display. However, if a value out of range was entered, no action is taken.
- o key: 6 (keypad)
text: Locate field
action: Moves cursor to a selected field. The field can be selected by searching for a character string on the display or by moving a number of fields forward. However, if a value out of range was entered, no action is taken. (See Locate Field Options for more information).

Display/Menu Status Options

Display/menu status options control the status of the display and menu and are available only from one of the main menus.

- o key: 1 (keypad)
text: Accept display
action: Accepts values for all fields and terminates edit of the present display. If a value out of range is entered, no action is taken.
- o key: PF4 (keypad)
text: Reset display
action: All fields are reset to the values they had at the beginning of the present edit session for the current display for most applications. (See Accepting and Resetting Display for exceptions.)
- o key: , (keypad)
text: Menu/no menu
action: Acts as a toggle switch to show or suppress the display of options in a menu area. If this key is selected while options are displayed, the options menu will be suppressed. If the key is selected while options are suppressed, the options menu will be displayed.

Main Menu Options - Not an item list field

These options are exclusive to the main menu when the current field does not have an item list.

- o key: Left arrow
text: Previous character
action: Moves the cursor from the present character in the present field to the previous character in the present field. If cursor is positioned at the first character in the field, no action is taken.
- o key: Right arrow
text: Next character
action: Moves the cursor from the present character in the present field to the next character in the present field. If cursor is positioned at last character in the field, no action is taken.
- o key: Any key from the keyboard
text: Character-by-character entry
action: Any keyboard character entered is placed on the screen at present cursor position and the cursor is moved to the next character in the field. Signs (+/-) must be the first character in the field or the user must replace a sign. Decimal points cannot be entered (except for alphanumeric fields as they are frozen. The value of the field is not checked against the range until the cursor is moved to another field or the display is accepted. This option is useful to change a single incorrect digit or character. All integer fields are assumed to be right justified. In a field which allows for seven digits, 1000 followed by 3 blanks would be interpreted as 1,000,000 and not 1000. For 1000, enter 3 blanks and then 1000.
- o key: PF1 (keypad)
text: Change entire field
action: Allows for entry of an entire field as opposed to character-by-character entry. The present field takes on the value entered; integer and character data fields are right justified. If a value out of range is entered, the present value is not changed. (See Changing Entire Field Options for more information.)

Main Menu Options - Item List Field

These options are exclusive to the main menu when the current field has an item list.

- o key: 7 (keypad)
text: Previous list item
action: Replaces value of present field with the previous value from the item list.

- o key: 8 (keypad)
text: Next list item
action: Replaces value of present field with the next value from the item list.
- o key: 9 (keypad)
text: Search item list
action: Searches the item list for a selected value. If value is found, the value of present field is replaced by selected value. (See Searching Item List Options for more information.)
- o key: - (keypad)
text: View item list
action: Displays the values available in an item list. A new value for the present field can be chosen from the item list. (See Viewing Item List Options for more information.)

Print Display Options

These options are exclusive to the print display menu.

- o key: Any key from the keyboard
text: Loads the input buffer.
action: The input buffer is the region of the menu following the prompt "input or option> " and the value entered is the name of the file to which the screen is to be written. Any legal file name may be entered; however, if a version number is specified, the file must be new. Any keyboard character entered is placed on the screen at the present cursor position, and the cursor is advanced. Once the input buffer is full no more characters may be entered. The delete key deletes the last character in the input buffer.
- o key: CR (RETURN)
text: Terminates input
action: Accepts the file name entered in the input buffer and attempts to open that file. If the file is opened, selected displays are written to it. The file will be empty if the program is aborted.

Locate Field Options

These options are exclusive to the locate field menu.

- o key: Any key from the keyboard
text: Loads the input buffer
action: The input buffer is the region of the menu following the prompt 7"input or option> " and the value entered is either the label of the desired field, the value of the desired field, or the number of fields to advance as indicated by the instruction in the first line of the menu.

Any keyboard character entered is placed on the screen at the present cursor position, and the cursor is advanced.

If entering the number of fields to advance, only digits 0-9 may be entered.

Once the input buffer is full no more characters may be entered. The delete key deletes the last character in the input buffer.

- o key: 4 (keypad)
text: Locate field by label or data
action: Indicates that the input buffer contains a label or data value. This is the default mode.
- o key: 5 (keypad)
text: Move forward several fields
action: Indicates that the input buffer contains the number of fields to advance (range 1 - 100).
- o key: CR (RETURN)
text: Terminates input
action: The cursor is advanced the specified number of fields or the screen is searched for a match to the input buffer and, if a match is found, the cursor is advanced to the field containing the value or to the field following the label. If no match is found, no action is taken.

Changing Entire Field Options

These options are exclusive to changing the entire field menu.

- o key: Any key from the keyboard
text: Loads the input buffer
action: The input buffer is the region of the menu following the prompt "input or option> " and the value entered is the new value for the selected field (flashing on screen). Any keyboard character entered is placed on the screen at the present cursor position and the cursor is advanced. For numeric data, signs (+/-) must be the first character in the input buffer and only digits 0-9 or decimal points may be entered.

Once the input buffer is full no more characters may be entered. The delete key deletes the last character in the input buffer.
- o key: CR (return)
text: Terminates input
action: Send the value entered in the input buffer to the selected field. If the value is out of range, the present value for the field is unchanged.

Searching Item List Options

These options are exclusive to the searching item list menu.

- o key: Any key from the keyboard
- text: Loads the input buffer
- action: The input buffer is the region of the menu following the prompt "input or option> " and the value entered is any unique description of the desired value for the selected field (flashing on screen). To locate "FEET," for example, enter "FE".

Any keyboard character entered is placed on the screen at the present cursor position, and the cursor is advanced.

Once the input buffer is full no more characters may be entered. The delete key deletes last character in the input buffer.

- o key: CR (RETURN)
- text: Terminates input
- action: Searches the item list for the value entered. If found, the complete value is sent to the selected field.

Viewing Item List

These options are exclusive to the viewing item list menu. The current item is displayed in reverse video.

- o key: Key a - ? from the keyboard
- text: Choose new value
- action: The item list is displayed one set of values at a time. Each value displayed is associated with a letter (? is representative of the letter for the last value displayed). When a valid letter is entered from the keyboard, the current item becomes the item associated with the letter entered.
- o key: 4 (keypad)
- text: Previous page
- action: Displays the page which precedes the current page displayed and sets the current item to the last item on the new page.
- o key: 5 (keypad)
- text: Next page
- action: Displays the page which follows the current page displayed and sets the current item to the first item on the page.
- o key: 6 (keypad)
- text: Accept current value
- action: Accepts the current value as the value for the present field.

- o key: Up Arrow
text: Previous item
action: Sets the previous item as the current item. If at the top of a page, the previous page is displayed and the last item on the new page becomes the current item.
- o key: Down Arrow
text: Next item
action: Sets the next item as the current item. If at the bottom of a page, the next page is displayed and the first item on the new page becomes the current item.
- o key: 0 (keypad)
text: Cancel
action: Returns the item which was the current item when the VIEW ITEM LIST display was entered (ignores item selected through the VIEW ITEM LIST display).

HELP

An online help facility is available to programs which use the screen data editor. When a request for help is made while editing a display, the help text for the present data field is displayed. The help session can be ended by pressing ENTER on the keypad. Help text for the edit commands can be displayed by pressing CR (return). General help text for the program or display can be displayed (if available) by pressing PF3 on the keypad. General help text can also be displayed by programs using the screen data editor in one of two other ways--either automatically or through a program dependent menu.

When viewing help text for the screen data editor edit commands or a general help text for a program or display, two options are available. The help session can be ended (control returned to the previous screen) by pressing ENTER on the keypad or more help text can be viewed by pressing CR (return).

SPECIAL INPUT REQUESTS

Programs using the screen data editor usually allow editing on all data fields within a display at the same time. This is referred to as the full-screen edit mode.

Programs may request, however, a value for a specific field without allowing edits on the entire display. This is referred to as the one-field edit mode.

If the data field contains an item list, the view item list menu will be displayed. A new value should be selected from this list. If the data field does not contain an item list, the field for which a new value is being requested will flash and the Change Entire Value menu will be displayed. A new value should be input.

FLOW OF EDITING

The general flow of an edit session is to select a field, request help if not certain what data that field contains, and enter a new value for the field if desired. To reset the display and all data fields to the values as they existed

at the beginning of the edit session, press PF4 on the keypad. To obtain a file copy of the screen as it presently exists, press . on the keypad.

Selecting a field

There are two ways to select a field as the data field to be edited:

- o Press either the down arrow (next field) or the up arrow (previous field) until the desired field is shown in reverse video.
- o Press 6 on the keypad (locate field). Enter either the data or the label of the data field to be edited. To locate "Year," enter "Year" followed by a carriage return (be careful to enter "Year" and not "year" as upper case "Y" and lower case "y" are not considered the same).

Requesting help

If a data field is not defined by just the label or to obtain other help text, as detailed under the HELP section, press PF2 on the keypad.

Entering a new value

There are several ways to enter a new value. It is important in entering data that ranges for values are heeded, signs (+ or -) are entered either as the first character in a field or to replace an existing sign. Only digits or signs are entered for numeric data fields.

For data fields which do not contain an item list:

- o Replace only the offending characters. To change the year from 1986 to 1976, use the right arrow (next character) and left arrow (previous character) to position the cursor on the "8" and enter "7" (remember that data are entered from the keyboard, only options are selected from the keypad).
- o Replace the entire value. Press PF1 (changing entire field) and enter "1986" followed by a carriage return.

For data fields which do contain an item list:

- o Go through the item list a value at a time. To change the month to April, press 7 on the keypad (previous list item) or 8 on the keypad (next list item) until April appears in the data field.
- o Specifically request the value. To change the month to April, press 9 on the keypad (search item list) and enter "April." If "April" is a value in the item list, it will appear in the data field, otherwise a message of "item not found" will appear in the error message area. Note that only a unique portion of "April" needs to be entered to locate the value in the list. "Ap" would be enough. AP could also be entered; lowercase and uppercase letters are equivalent.

- o Select value from a list. To change the month to April, press - (view item list) on the keypad. The list of possible values will appear:

A January
B February
C March
D April
.
.
L December

Press D on the keyboard and "April" will appear highlighted in reverse video, or use the up and down arrow key to change the highlighted value until "April" is highlighted. Press 6 on the keypad to accept "April" as the value and return to the main display.

EDIT SESSION EXAMPLE

An edit session example called SCREENEX is available by entering the command RUN SCREENEX on any video terminal. SCREENEX uses two displays and demonstrates the full-screen edit mode, the one-field edit mode, full-screen editing on one display while another display is on the screen, and editing a display which is partially hidden by the menu.

ACCEPTING AND RESETTNG DISPLAYS

Three keys have the potential to affect the display as a whole from either of the main menus. These are the PF3 key (special functions), the l key (accept display) and the PF4 key (reset display). These keys may behave differently in each program. Consult each programs general help file for differences in the use of these keys.

- o The PF4 key will always reset all fields to the values they had at the beginning of the edit session for the current display if possible. Some programs, for various reasons, may be able to accomplish this or some programs may reset fields to the values they had the last time the "accept display" option or the "special functions" option was selected.
- o The l key will always accept the display and terminate the edit session except when the "special function" option controls the termination of editing. In such cases, the l key may "accept display" in that the values on the display will be the ones to which the "reset display" is reset.
- o The PF3 key will only be used in some programs and its functions will vary. For example, the PF3 key may control file access with the file access options stored in an item list, or it could be used to call up other data for display.